SEPTEMBER 2019

WIM #32
US 52, MP 66.0
ORONOCO, MN

MONTHLY REPORT

Your Destination...Our Priority

WIM Site Location

WIM #32 is located on US 52 near Oronoco in Olmsted county.

System Operation

WIM #32 was operational for the entire month of September 2019. Volume was computed using all monthly data.

System Calibration

WIM #32 was most recently calibrated on 2019-06-06. Table 1 summarizes the front axle weights of class 9s by lane [1]. Figure 1 shows the distribution of gross vehicle weights (GVW) in Class 9 vehicles at this site for the last 12 months of operation [2]. Figure 2 depicts the average front axle weight as a percent difference from the first full month following calibration.

Summary of Volume Statistics

Total Monthly Volume: 978335 | Passenger Vehicles: 900716 | Heavy Commercial Vehicles: 77619

Monthly Average Daily Traffic (MADT): 32323 | Monthly Heavy Commercial Average Daily Traffic (MHCADT): 2587

See Table 2 for vehicle class breakdown

Passenger Vehicles (PVs) and Heavy Commercial Vehicles (HCVs)

Volume trends. NB vehicles typically reached highest volume levels on Fridays, with lowest volumes reported on Tuesdays. SB vehicles typically reached highest volume levels on Fridays, with lowest volumes reported on Wednesdays (see Figure 3 and 4).

Passenger Vehicles (PVs)

Volume trends. On an average 24-hour day (see Figure 5), NB PVs generally reached peak volume levels between 03 PM and 05 PM. Similarly, SB PVs peaked in volume between 03 PM and 05 PM

Heavy Commercial Vehicles (HCVs)

Volume trends. On an average 24-hour day, HCVs traveling NB typically reached peak volume levels between 03 PM and 05 PM, while volume going SB peaked between 03 PM and 05 PM. See Figure 6. Out of all HCVs, the two highest traffic volumes were generated by Class 9's and Class 5's.

Overweight HCVs

Volume trends. Of a total of 77619 HCVs, 10020 of them were overweight [3]. These overweight HCVs contributed to 1.1% of total monthly volume, and 13.5% of total monthly

HCV volume. NB overweight vehicles typically reached highest numbers on Wednesdays, with lowest volumes reported on Sundays. SB overweight vehicles tended to reach highest volumes on Tuesdays, with lowest volumes reported on Sundays. See Figure 3 .
The top two overweight violators by class were the class 9 and class 10 vehicles . Overall, overweight vehicles tended to reach peak volume concentrations during typical business hours, with 62.1% of all overweight vehicles traveling NB this month (see Figure 7 & 8). Figure 9 shows the number of vehicles exceeding 88,000 pounds that crossed the WIM over the last 12 months. The highest number of 88,000+ vehicles within the last 12 months occurred in June.
WIMs are currently used as a screening tool for weight enforcement, and it is estimated that the WIM scales can measure gross vehicle weights (GVW) within 90-95% of static weight scale measurements. Due to the possibility of measurement error, vehicles exceeding 10% of their legal weight limits (or 1.1 times their legal weight limits) are considered overweight in this report [4].
Using normal load limits ,202 NB vehicles exceeded 88,000 pounds (90 vehicles were Class 9's; 58 vehicles were Class 13's). Of vehicles traveling SB,

180 NB vehicles exceeded 88,000 pounds (82 vehicles were Class 9's; 44 vehicles were Class 13's). Refer to Table 3 for the Top 10 highest recorded GVWs from Classes 9 and 10 from September 2019.

Loaded vs. Unloaded HCVs. Figure 10 shows the GVW distributions of Class 9s and 10s in September 2019. Data suggests that there were greater numbers of fully_loaded Class 9's than empty Class 9's traveling NB, while there were more fully_loaded Class 9's than empty traveling SB. Data also suggests that there were more fully_loaded Class 10's than empty traveling in the NB direction. In the SB direction, there were more fully_loaded class 10 vehicles.

Freight Totals. A total of 657672 tons of freight was recorded to have crossed the WIM. More freight was shipped NB (54.2%) than SB (45.8%). See Table 4 and Figure 11 for more freight information.

####**Infrastructure Considerations Bridge.** Bridge No. 55X13 (a box culvert) is approximately 1/3 of a mile north of WIM #32, and Bridge No. 8960 (a box culvert) is approximately 1 ¾ miles south of WIM #32. WIM #32 recorded a total of 978335 vehicles with a combined GVW of 7127456 kips (1 kip = 1,000 pounds = 0.5 tons) in September 2019. See Table 5 and Figures 12-13 for GVW information by vehicle class and lane.

Pavement Design. A total of 59485 equivalent single axle loads (ESALs) passed over the pavement at this site. Approximately 54.8% of all ESALs were recorded NB while 45.2% was observed SB. In particular, 77% of all ESALs were generated by the Class 9's (Class 9's were also responsible for generating 34% of total GVW observed this month). See Table 6 and Figures 14-15 for more information on ESALs (Table 6 also provides flexible ESAL factors for each vehicle class using a terminal serviceability of 2.5 and a structural number of 5).

#####WIM monthly reports can be found at:
http://www.dot.state.mn.us/traffic/data/reports-monthly-wim.html MnDOT's vehicle

classification scheme and vehicle class groupings for traffic forecasting can be found at: http://www.dot.state.mn.us/traffic/data/data-products.html#weight

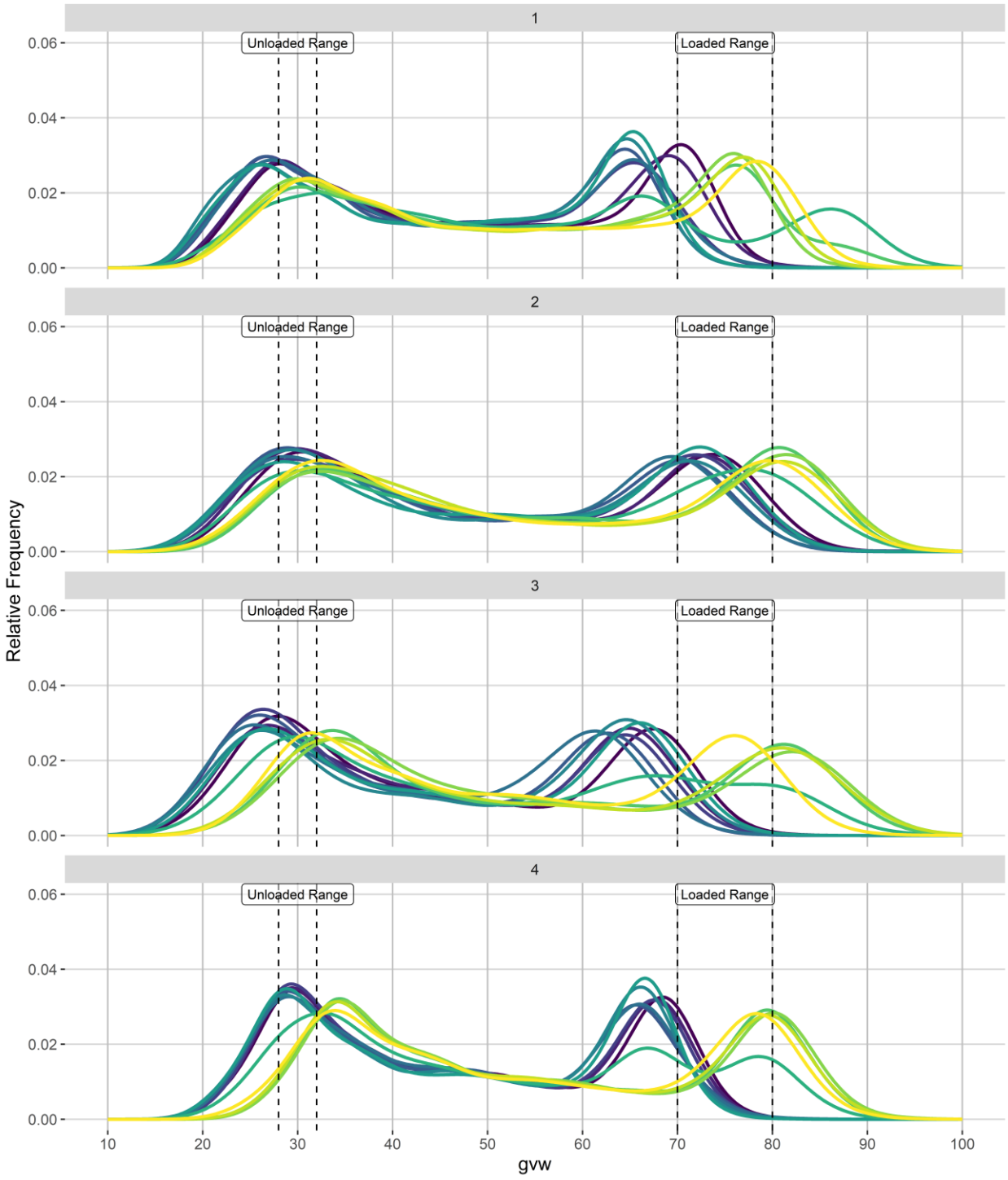
- [1] Front axle weights of Class 9s are monitored on a monthly basis to assure performance between calibrations. The current goal of the WIM scale calibration is to have each individual axle weight stay within a range of ?9% of baseline calibration values

- [2] Previous WIM research indicates that unloaded Class 9s typically weigh 28-32 kips, while loaded Class 9s generally fall in the 70-80 kip range. More recent data from several WIM sites suggests that the unloaded Class 9 range may have moved a little higher over time (due to increased presence of sleeper cabs, etc.), although these ranges are also thought to be site-specific.

- [3] An HCV is considered overweight during normal load limits in this report if they satisfy any of the following 1) exceed a gross vehicle weight (GVW) of 80,000 pounds, 2) exceed any of the legal weight maximums on any axle configurations (legal maximums are: single axle = 20,000 pounds; tandem axles spaced 8' or less = 34,000 pounds; tridem axles spaced 9' or less = 43,000 pounds; quad axles spaced 13' or less = 51,000 pounds). Monthly reports use this standard regardless of the time of year however, the Winter Load Increase (WLI) allows a 10% across the board increase in axle and gross vehicle weights without a permit on US, state routes, and county roads. An HCV is considered overweight during Winter Load Increase(WLI) if they satisfy any of the following 1) exceed a gross vehicle weight (GVW) of 88,000 pounds, 2) exceed any of the legal weight maximums on any axle configurations (legal maximums are: single axle = 22,000 pounds; tandem axles spaced 8' or less = 37,400 pounds; tridem axles spaced 9' or less = 47,300 pounds; quad axles spaced 13' or less = 56,100 pounds). An overweight HCV is only included once in the overweight volume calculations regardless of how many of the aforementioned conditions are violated. For information on MN weight limit dates and statutes: http://www.mrr.dot.state.mn.us/research/seasonal_load_limits/sllindex.asp

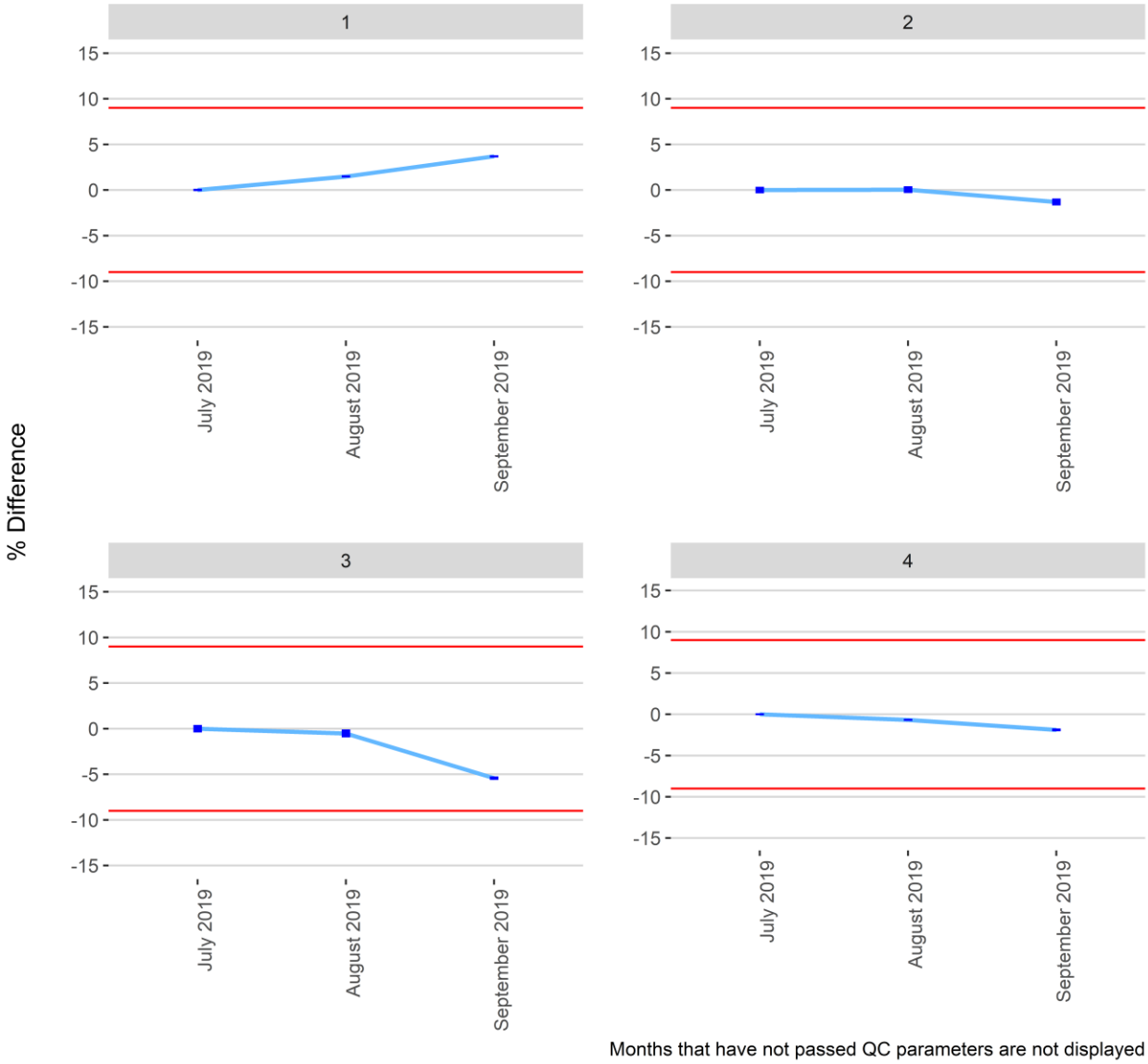
- [4] For example, Class 9s and 10s can legally have gross vehicle weights up to 80,000 lbs (with the exception of permitted loads) during normal load limits. To account for measurement error on the WIM scales, those exceeding 10% of the legal GVW maximum (or 1.1 times the legal GVW) should be screened (e.g., 80,000 lbs + 8,000 lbs = 88,000 lbs). Similarly during WLI vehicles weighing 96,800 lbs should be screened.

Figure 1 - Monthly Class 9 GVW Histogram



Months that have not passed QC parameters are not displayed

Figure 2 - Percent Difference of Front Axle Weight from Last Calibration (+/- 95% CI)



Months that have not passed QC parameters are not displayed

Figure 2 - Average Vehicle Volume vs. Day of the Week

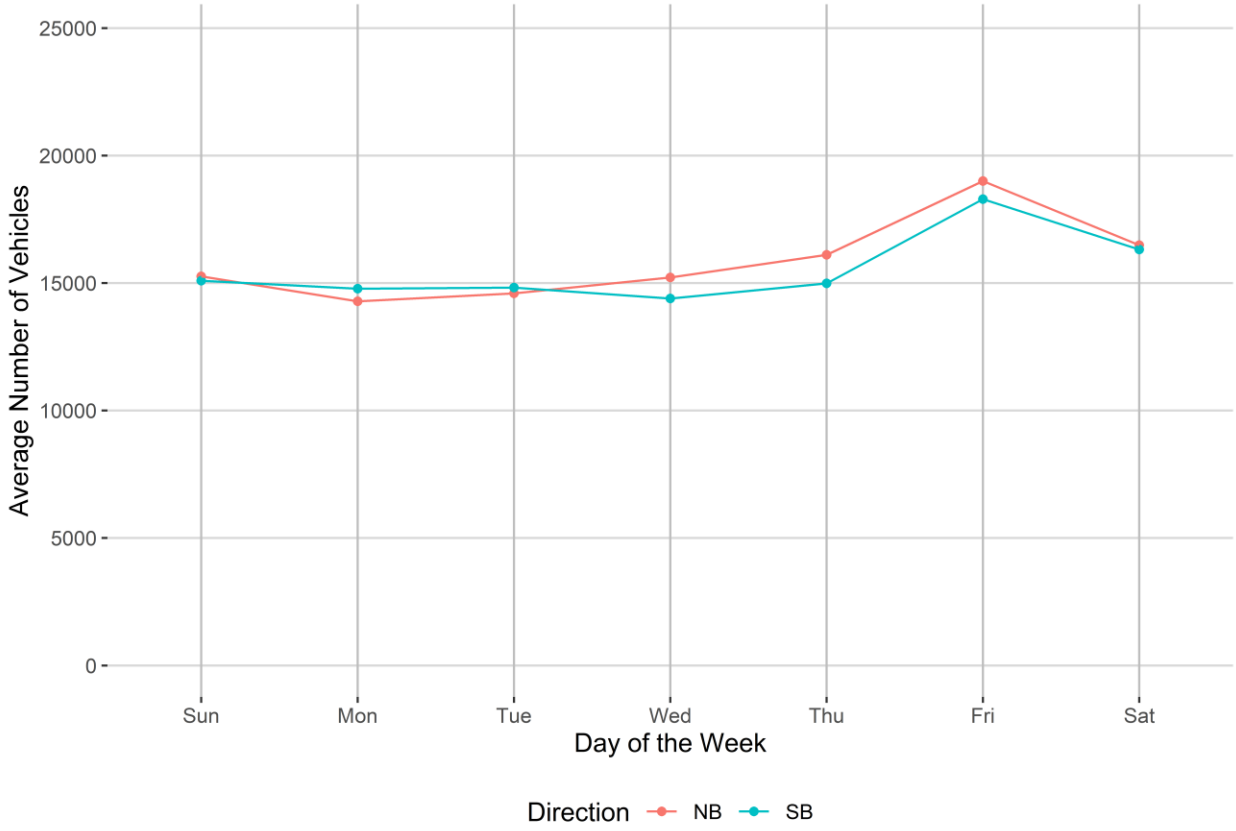


Figure 3 - Average Overweight Vehicle Volume vs. Day of the Week

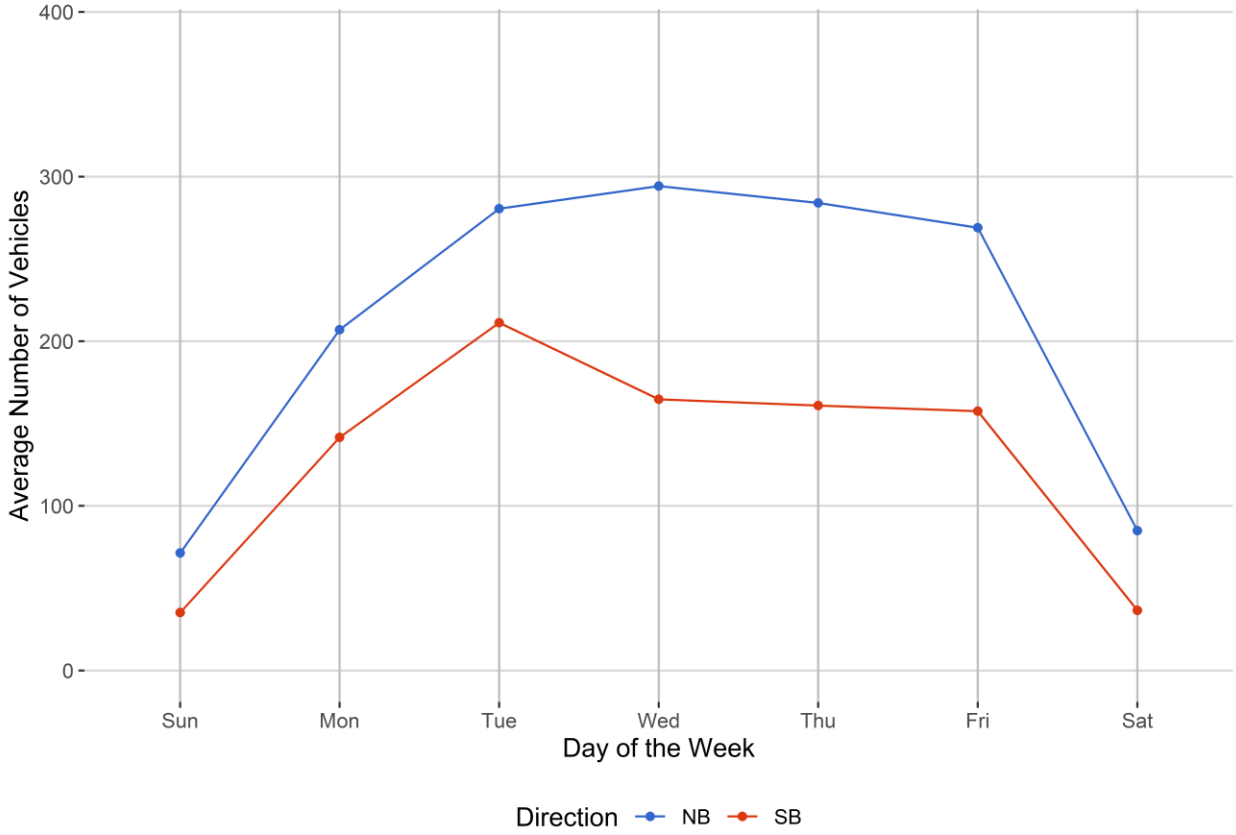


Figure 4 - Passenger Vehicles
vs. Hour of the Day

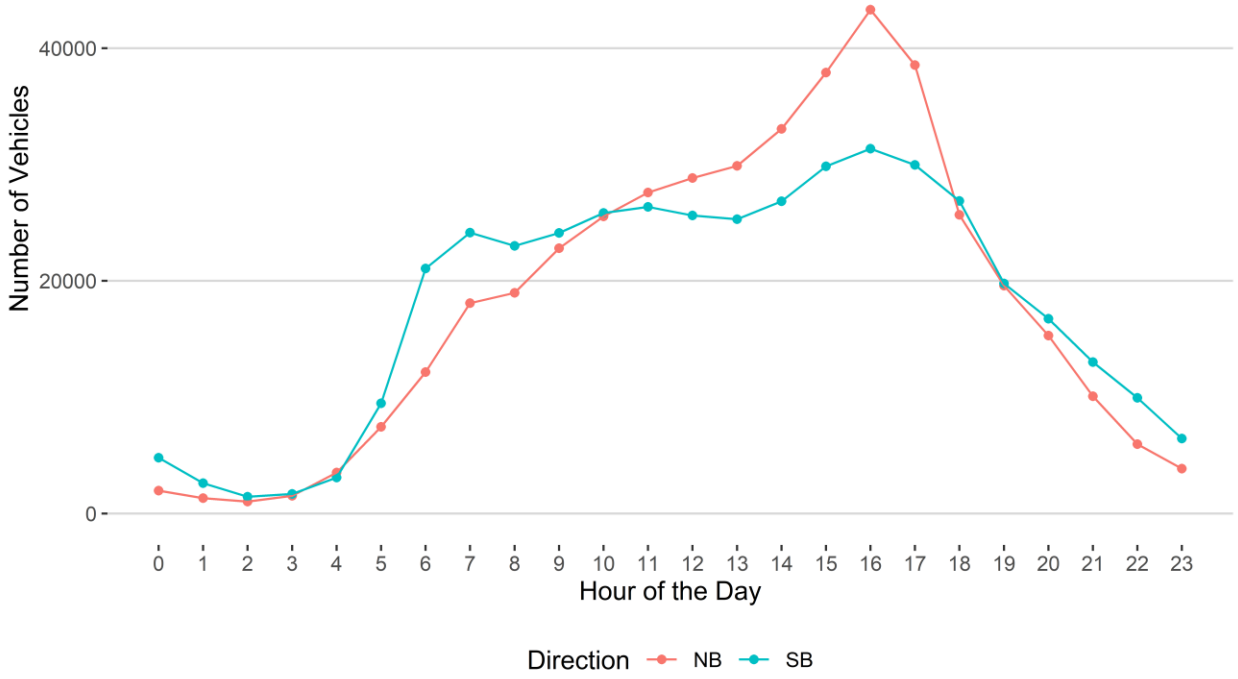


Figure 5 - Heavy Commercial Vehicles
vs. Hour of the Day

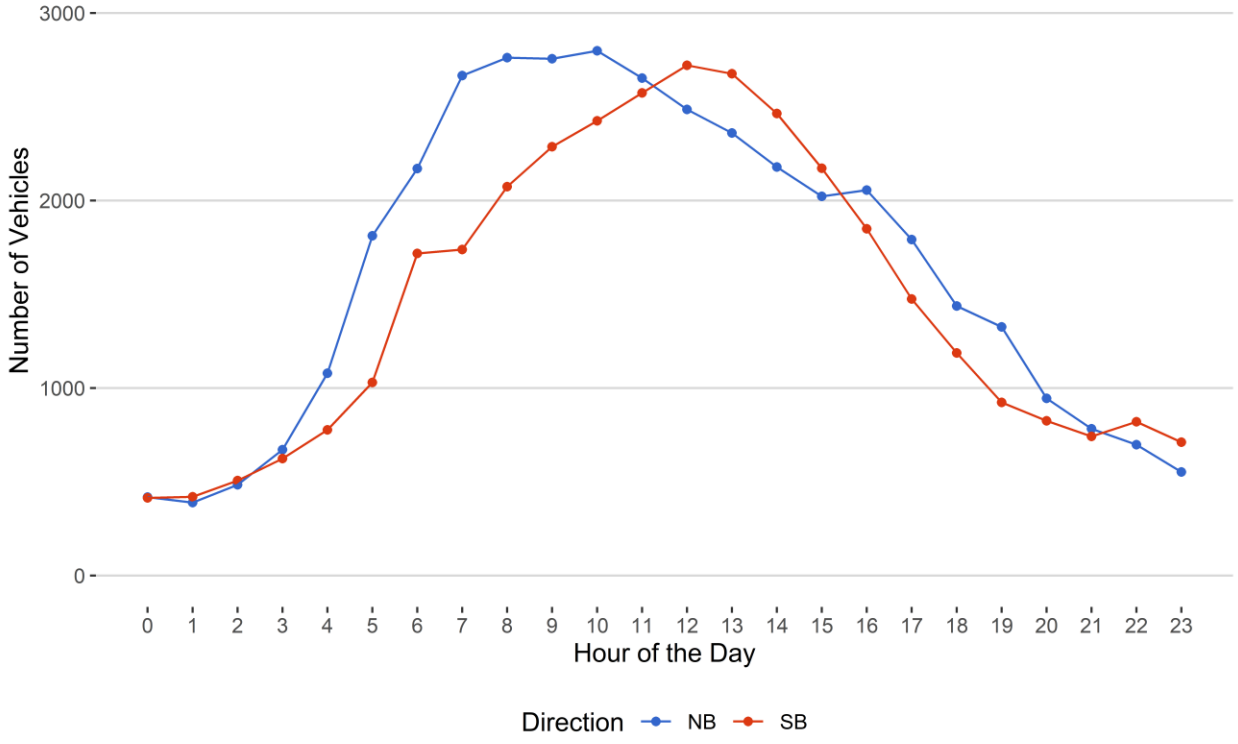


Figure 6 - Overweight Vehicles by Class vs. Hour of the Day

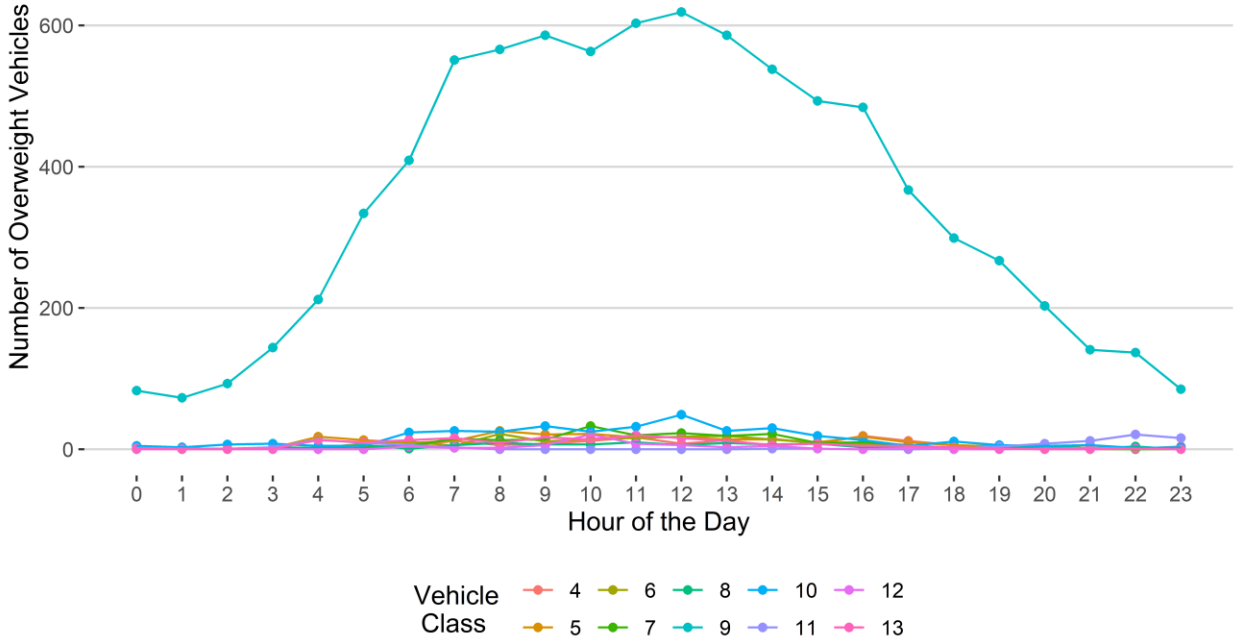


Figure 7 - Overweight Vehicles by Direction
Hour of the Day

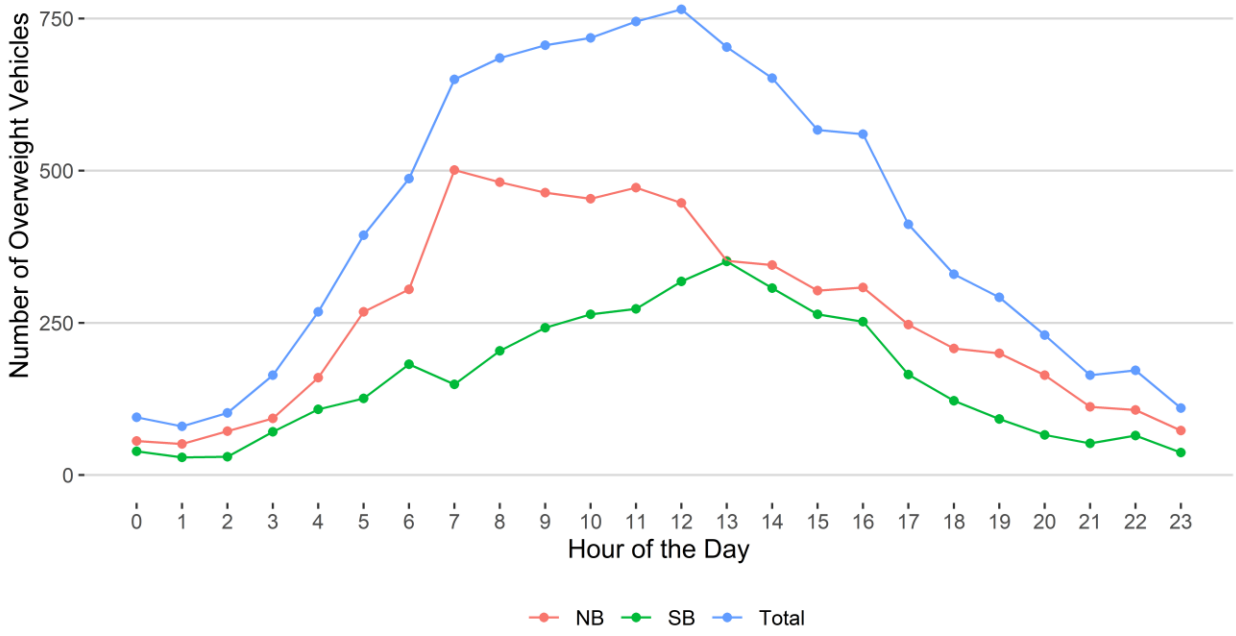
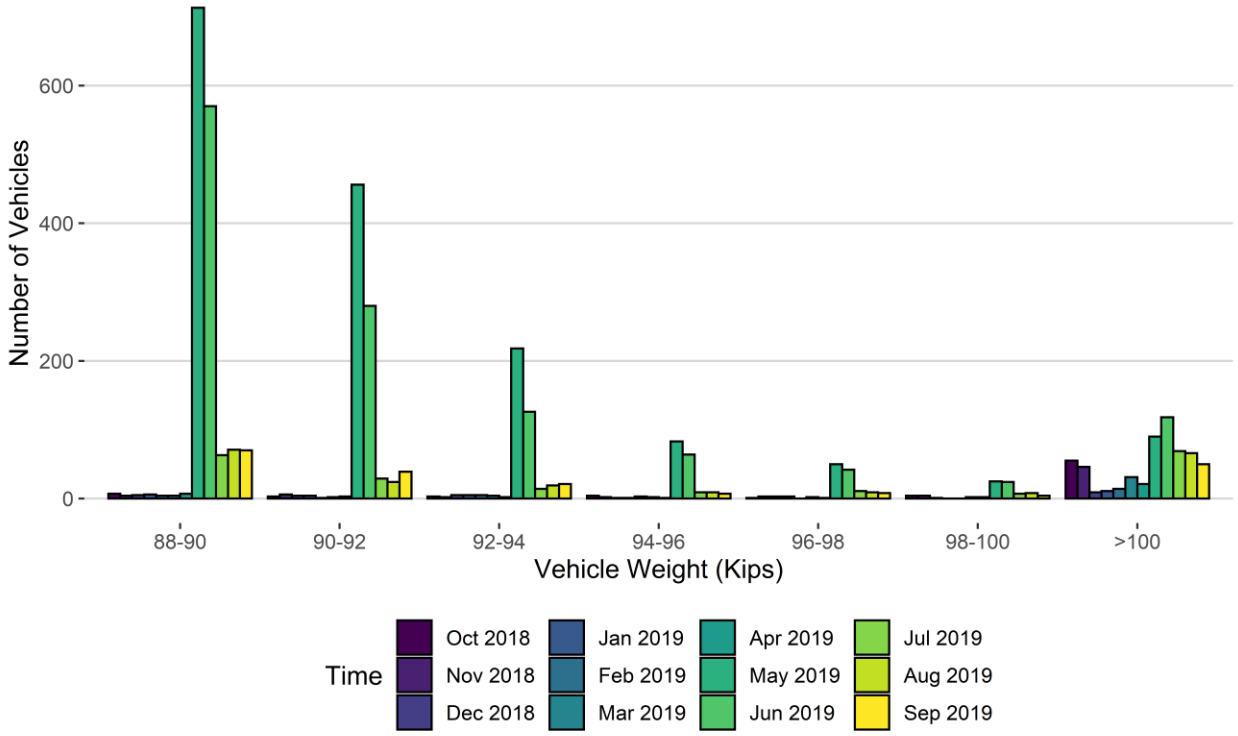
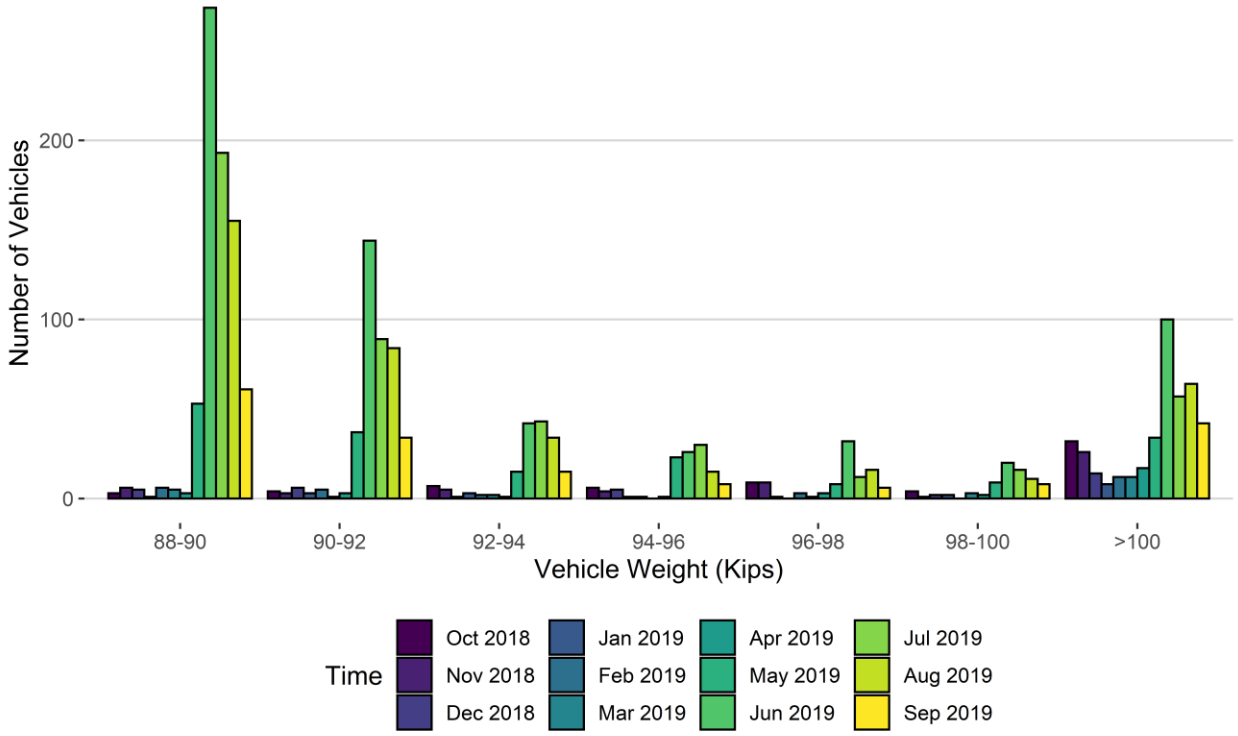


Figure 8 - Histogram of NB Vehicles Over 88,000 Pounds for Current Month



Vehicle Weights (Kips)	*Oct 2018*	*Nov 2018*	*Dec 2018*	*Jan 2019*	*Feb 2019*	*Mar 2019*	*Apr 2019*	*May 2019*	*Jun 2019*	*Jul 2019*	*Aug 2019*	*Sep 2019*
88-90	7	4	5	6	4	4	7	713	570	63	71	70
90-92	3	6	4	4	1	2	3	456	280	29	24	39
92-94	3	2	5	5	5	4	2	218	126	14	19	21
94-96	4	2	1	1	3	2	1	83	64	9	9	7
96-98	1	3	3	3	0	2	1	50	42	11	9	8
98-100	4	4	1	0	0	2	2	25	24	7	8	4
>100	55	46	9	11	14	31	21	90	118	69	66	50
Total	77	67	28	30	27	47	37	1635	1224	202	206	199

Figure 8 - Histogram of SB Vehicles Over 88,000 Pounds for Current Month



Vehicle Weights (Kips)	*Oct 2018*	*Nov 2018*	*Dec 2018*	*Jan 2019*	*Feb 2019*	*Mar 2019*	*Apr 2019*	*May 2019*	*Jun 2019*	*Jul 2019*	*Aug 2019*	*Sep 2019*
88-90	3	6	5	1	6	5	3	53	274	193	155	61
90-92	4	3	6	3	5	1	3	37	144	89	84	34
92-94	7	5	1	3	2	2	1	15	42	43	34	15
94-96	6	4	5	1	1	0	1	23	26	30	15	8
96-98	9	9	1	0	3	1	3	8	32	12	16	6
98-100	4	1	2	2	0	3	2	9	20	16	11	8
>100	32	26	14	8	12	12	17	34	100	57	64	42
Total	65	54	34	18	29	24	30	179	638	440	379	174

Figure 8 - Class 9's and 10's by Direction vs Gross Vehicle Weight

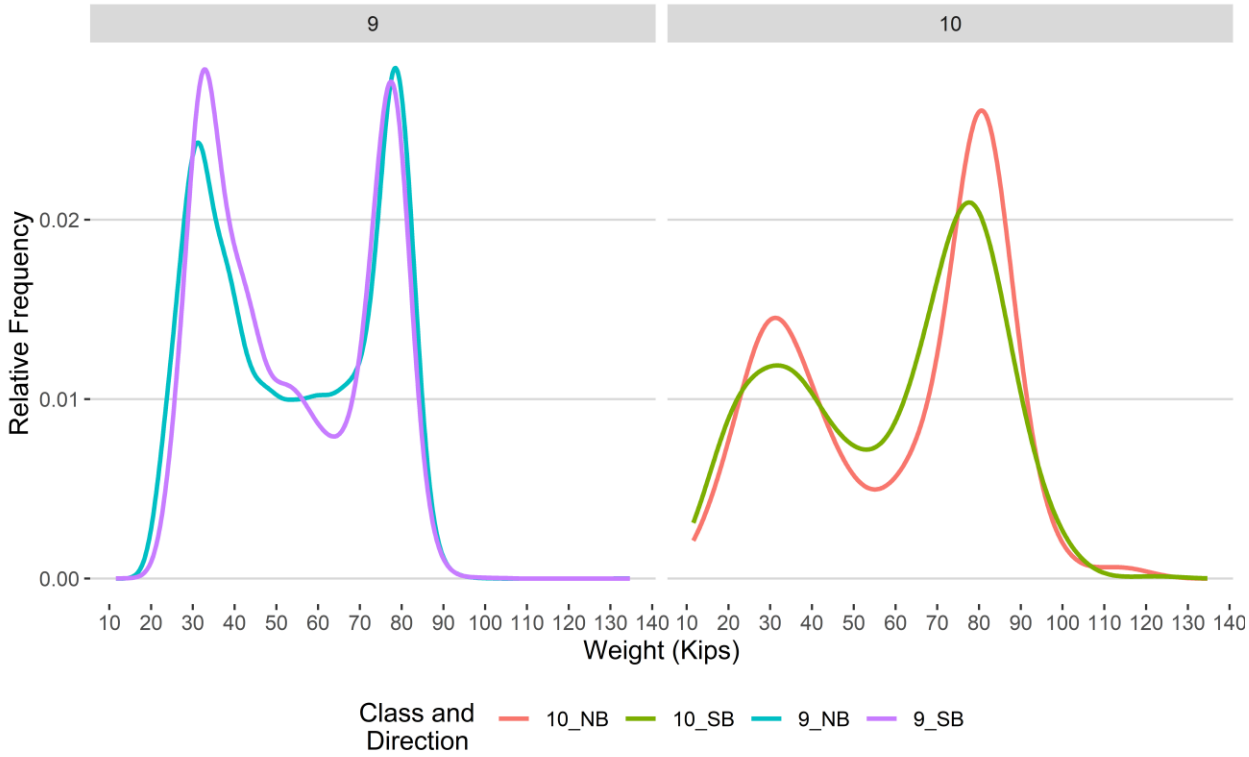


Figure 9 - Freight Percentage by Direction and Class

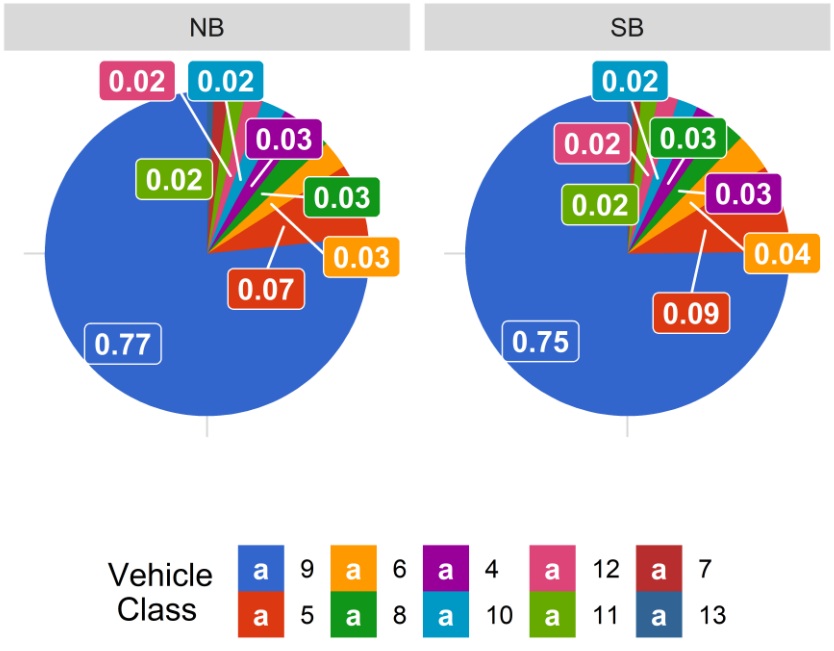


Figure 10 - Total Gross Vehicle Weight Percentage by Class and Lane

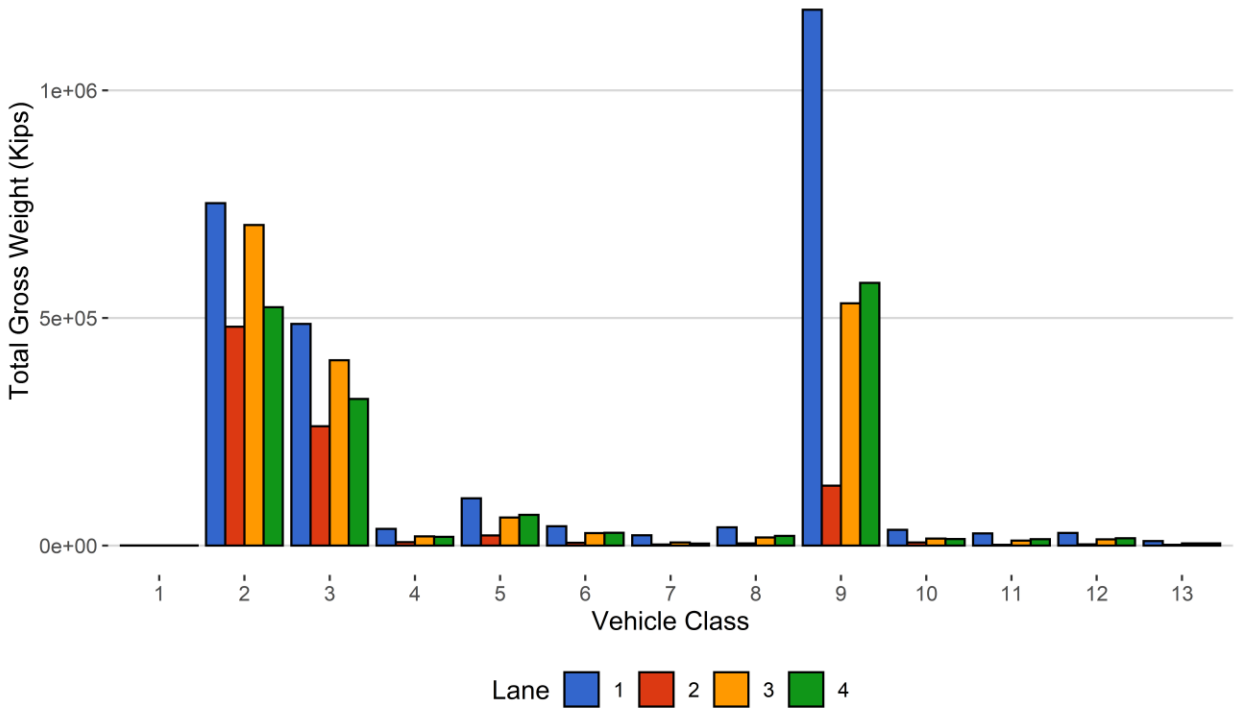


Figure 11 - Total Gross Vehicle Weight

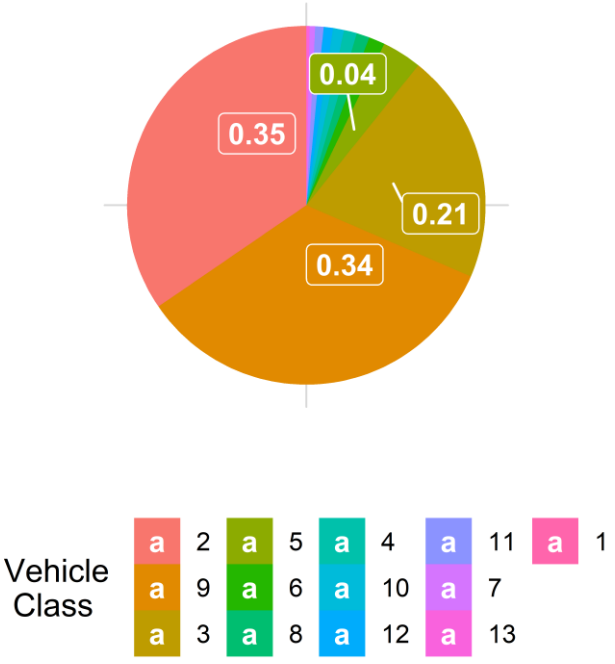


Figure 12 - Total ESALs by Class and Lane

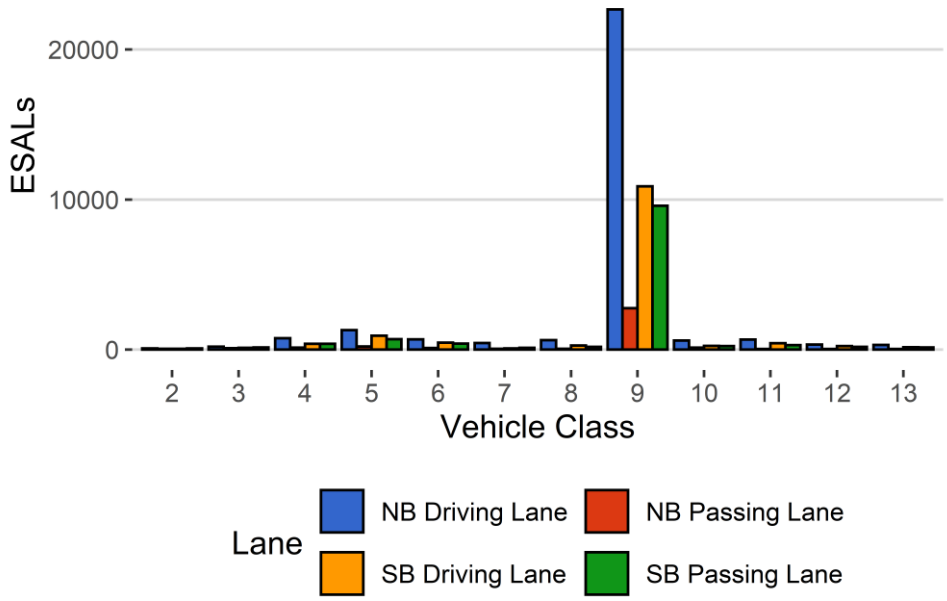


Figure 13 - ESALs by Class

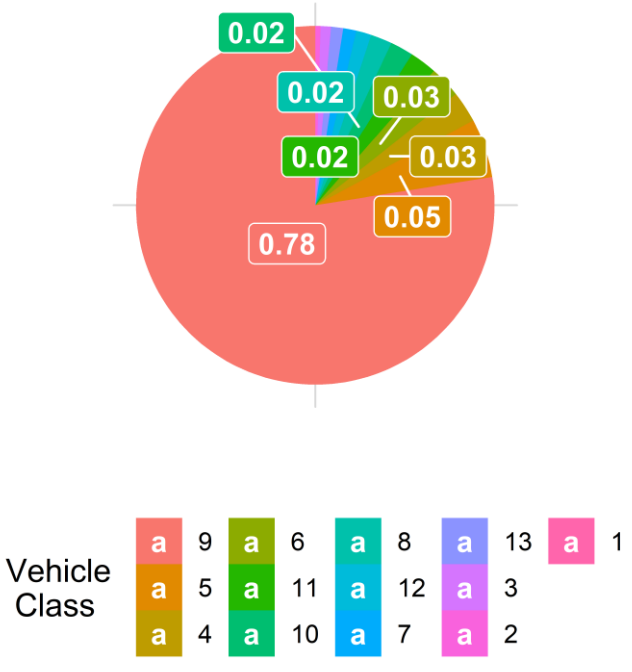


Table 1 Class 9 Front Axle Weight by Lane

Month	*Lane 1 (Kips)*	*Front Axle +/- 9%*	*Lane 2 (Kips)*	*Front Axle +/- 9%*	*Lane 3 (Kips)*	*Front Axle +/- 9%*	*Lane 4 (kips)*	*Front Axle +/- 9%*
July 2019	10.23	0.00	11.64	0.00	11.83	0.00	11.75	0.00
August 2019	10.38	1.48	11.65	0.04	11.77	-0.52	11.67	-0.68
September 2019	10.61	3.69	11.49	-1.31	11.19	-5.43	11.53	-1.89

Table 2 Vehicle Classification Data

Vehicle Class	*Monthly Average Daily Volume*	*Monthly Total Volume*	*Monthly Total Volume Percentage*	*Monthly Total Overweight Vehicles*	*Monthly Total Overweight Percentage*
1	9	255	0	0	0
2	21691	650724	66.5	0	0
3	8325	249736	25.5	0	0
4	89	2660	0.3	160	1.6
5	599	17960	1.8	245	2.4
6	122	3650	0.4	173	1.7
7	20	614	0.1	196	2
8	96	2872	0.3	99	1
9	1548	46431	4.7	8436	84.2
10	41	1228	0.1	373	3.7
11	32	946	0.1	103	1
12	35	1037	0.1	64	0.6
13	7	221	0	171	1.7
TOTAL	**32611**	**978335**	**100**	**10020**	**100**

Table 3 Top 10 Gross Vehicle Weight, Class 9 and 10

Date	*Day of Week*	*Time*	*Vehicle Class*	*Direction*	*Lane*	*GVW (lbs)*
2019-09-27	Friday	03:28:26	9	NB	1	134.67
2019-09-06	Friday	03:11:26	9	NB	1	131.87
2019-09-04	Wednesday	02:57:25	9	NB	1	131.12
2019-09-30	Monday	06:06:06	10	SB	3	122.29
2019-09-20	Friday	02:08:46	9	NB	1	121.65
2019-09-13	Friday	18:33:01	10	NB	1	117.2
2019-09-18	Wednesday	17:05:30	10	NB	1	116.98
2019-09-30	Monday	14:02:28	10	NB	1	116.94
2019-09-06	Friday	15:52:25	10	NB	1	113.01
2019-09-10	Tuesday	17:37:26	10	NB	1	112.72

Table 4 Freight Summary

Vehicle Class	*Direction*	*Weight of Empty Vehicle (Kips)*	*Total Number of Vehicles*	*Number of Empty Vehicles*	*Percentage of Empty Vehicles*	*Total Weight of Vehicles with Freight (Kips)*	*Total Weight of Empty Vehicles (Kips)*	*Total Weight of Freight (Tons)*
4	NB	15	1337	108	8.1	42524	1384	12044
5	NB	8	8619	737	8.6	120549	5441	28746
6	NB	19	1669	400	24	41481	6661	8685
7	NB	11.5	393	0	0	24788	0	10134
8	NB	31	1470	831	56.5	25263	19317	2727
9	NB	33	23996	5156	21.5	1161445	147004	269863
10	NB	33.5	676	153	22.6	36979	4043	9729
11	NB	36.5	499	29	5.8	27613	837	5229
12	NB	36.5	521	43	8.3	28967	1474	5760
13	NB	31.5	115	1	0.9	11212	21	3811
TOTAL	****	****	**39295**	**7458**	****	**1520822**	****	**356729**
Vehicle Class	Direction	Weight of Empty Vehicle (Kips)	Total Number of Vehicles	Number of Empty Vehicles	Percentage of Empty Vehicles	Total Weight of Vehicles with Freight (Kips)	Total Weight of Empty Vehicles (Kips)	Total Weight of Freight (Tons)
4	SB	15	1214	114	9.4	37500	1500	10500
5	SB	8	8607	761	8.8	123415	5529	30324
6	SB	19	1832	248	13.5	50890	4238	10397
7	SB	11.5	196	0	0	10940	0	4343
8	SB	31	1285	700	54.5	22165	16446	2015
9	SB	33	20538	3747	18.2	998331	110565	222114
10	SB	33.5	502	105	20.9	27098	2567	6899
11	SB	36.5	408	27	6.6	24071	813	5082
12	SB	36.5	474	6	1.3	29310	185	6114
13	SB	31.5	97	1	1	9335	20	3155
TOTAL	****	****	**35153**	**5709**	****	**1333053**	****	**300943**
GRAND TOTAL	****	****	**74448**	**13167**	**290**	**2853875**	**328043**	**657672**

Table 5 Gross Vehicle Weight by Class and Lane

Vehicle Class	*NB Driving Lane*	*NB Passing Lane*	*SB Passing Lane*	*SB Driving Lane*	*Total*	*Percentage*
1	100	45	96	80	320	0
2	751957	480723	703942	523331	2459953	34.6
3	486881	262125	406901	321872	1477778	20.8
4	36560	7347	20062	18937	82907	1.2
5	103839	22151	61438	67506	254934	3.6
6	42234	5908	27261	27867	103270	1.5
7	22591	2198	6558	4382	35729	0.5
8	39864	4715	17528	21083	83191	1.2
9	1176991	131458	531949	576947	2417345	34
10	34454	6568	15340	14325	70687	1
11	26724	1726	10873	14011	53334	0.7
12	27715	2726	13615	15880	59936	0.8
13	9829	1404	4715	4640	20588	0.3
TOTAL	**2759739**	**929094**	**1820278**	**1610860**	**7119971**	**100**
GVW/LANE	**38.76**	**13.05**	**25.57**	**22.62**	**100**	**0**

Table 6 ESALs by Class and Lane and Flexible ESAL Factors

Vehicle Class	*NB Driving Lane*	*NB Passing Lane*	*SB Passing Lane*	*SB Driving Lane*	*Total*	*Percentage*	*Flexible ESAL Factor*
1	0	0	0	0	0	0	0.0041
2	80	56	80	61	278	0.47	9e-04
3	196	92	140	122	551	0.93	0.0046
4	756	136	390	396	1678	2.83	1.32
5	1304	216	693	925	3137	5.3	0.36
6	687	102	407	472	1667	2.81	0.95
7	446	51	120	83	700	1.18	2.36
8	634	54	182	275	1145	1.93	0.83
9	22672	2758	9588	10886	45904	77.53	2.06
10	612	129	240	254	1235	2.09	2.09
11	672	49	296	434	1451	2.45	3.18
12	345	47	187	233	812	1.37	1.63
13	312	41	143	154	649	1.1	5.83
TOTAL	**28714**	**3731**	**12465**	**14295**	**59205**	**100**	**21**
ESALS/LANE	**48.5**	**6.3**	**21.1**	**24.1**	**100**	**–**	**–**

Table 7 Site Summary: Volume and Vehicle Class

Month	*Total Volume*	*Monthly ADT*	*Monthly HCADT*	*Passenger Vehicles*	*Passenger Vehicles %*	*Heavy Commercial Vehicles*	*Heavy Commercial Vehicles %*	*Heavy Commercial Vehicles in Driving Lane %*	*Heavy Commercial Vehicles in Passing Lane %*
Oct 2018	1005115	32423	2741	920135	91.5	84980	8.5	89	11
Nov 2018	807078	31042	2150	742577	92	64501	8	88.3	11.7
Dec 2018	864651	28822	2035	801570	92.7	63081.4	7.3	89.2	10.8
Jan 2019	786295	25364	2059	722455	91.9	63839.9	8.1	88.7	11.3
Feb 2019	682508	24375	2079	624284	91.5	58224	8.5	82.2	17.8
Mar 2019	904406	29174	2268	834104	92.2	70302.3	7.8	88.7	11.3
Apr 2019	922175	30739	2481	847749	91.9	74425.7	8.1	88.3	11.7
May 2019	1039153	33329	2670	956381	92	82771.9	8	87.5	12.5
Jun 2019	1022960	34099	2622	944302	92.3	78658.4	7.7	86.8	13.2
Jul 2019	1058475	34221	2702	974717	92.1	83757.7	7.9	87.2	12.8
Aug 2019	1096548	35208	2723	1012139	92.3	84409.1	7.7	88	12
Sep 2019	978335	32323	2587	900716	92.1	77619.2	7.9	70.3	29.7
TOTAL	**11167699**	**–**	**–**	**10281129**	**–**	**886571**	**–**	**–**	**–**
AVERAGE	**930642**	**30927**	**2426**	**856761**	**92**	**73881**	**8**	**86**	**14**

###ESALs

Month	*ESALS NB Passing Lane*	*ESALS NB Driving Lane*	*ESALS SB Driving Lane*	*ESALS SB Passing Lane*	*Total ESALS*	*Driving Lane ESALS %*	*Passing Lane ESALS %*	*Pavement Life Decrease Months*
Oct 2018	20621	3073	1569	17666	42930	89	11	1.1
Nov 2018	16547	2620	1352	14453	34973	89	11	1.2
Dec 2018	12208	2206	1054	12749	28217	88	12	0.2
Jan 2019	10858	2006	1055	11960	25880	88	12	0.3
Feb 2019	8685	2828	1545	10833	23891	82	18	0.3

Mar 2019	12211	2429	1320	13607	29567	87	13	0.1
Apr 2019	13454	2771	1525	14186	31936	87	13	0
May 2019	32259	4042	3006	23513	62819	89	11	21.3
Jun 2019	53625	10086	7472	58409	129592	86	14	3.4
Jul 2019	25138	4916	4146	32194	66394	86	14	4.4
Aug 2019	27967	4501	3840	31466	67774	88	12	3.9
Sep 2019	28842	3734	12568	14341	59485	73	27	2.5
TOTAL	**262416**	**45211**	**40452**	**255377**	**603457**	**–**	**–**	**–**
AVERAGE	**21868**	**3768**	**3371**	**21281**	**50288**	**86**	**14**	**3**

###Gross Vehicle Weight

Month	*GVW NB Passing Lane*	*GVW NB Driving Lane*	*GVW SB Passing Lane*	*GVW SB Driving Lane*	*Total GVW Kips*
Oct 18	2663414	939774	748845	2610840	6962873
Nov 18	2335826	846388	669420	2308649	6160283
Dec 18	2086264	770010	604432	2166104	5626811
Jan 19	1876590	646522	520347	1994371	5037829
Feb 19	1423377	652606	530116	1737913	4344012
Mar 19	2086856	798781	620139	2233229	5739005
Apr 19	2203311	844134	673418	2294631	6015495
May 19	2887575	1038509	896554	2762671	7585308
Jun 19	5370351	2138820	1938350	5817580	15265101
Jul 19	2756663	1092970	1018131	3103868	7971633
Aug 19	2918571	1091245	1004179	3150967	8164962
Sep 19	2762888	929295	1822629	1612644	7127456
TOTAL	**31371687**	**11789053**	**11046560**	**31793467**	**86000767**
AVERAGE	**2614307**	**982421**	**920547**	**2649456**	**7166731**

###Overweight Vehicles

Month	*Total Number of Overweight Vehicles*	*Overweight / Total Volume*	*Overweight / Heavy Commercial Volume*	*Number Over 88,000 lbs*	*Number Over 98,000 lbs*
Oct 2018	1564	0.2	1.9	142	95
Nov 2018	1176	0.1	1.6	125	77
Dec 2018	728	0.1	1.1	66	27
Jan 2019	575	0.1	0.9	48	21
Feb 2019	794	0.1	1.4	56	26
Mar 2019	591	0.1	0.9	71	48
Apr 2019	563	0.1	0.8	70	42
May 2019	9712	1	11.9	1831	162
Jun 2019	22320	1.1	14.5	1866	262

Jul 2019	11264	1.1	13.7	645	150
Aug 2019	11662	1.1	14.1	585	149
Sep 2019	10051	1.1	13.4	382	112
TOTAL	**71000**	**–**	**–**	**5887**	**1171**
AVERAGE	**5916.7**	**0.5**	**6.3**	**490.6**	**97.6**

###Freight

Month	*NB Freight Tons*	*SB Freight Tons*	*Total Freight*	*NB Freight %*	*SB Freight %*
Oct 2018	321475	280646	602121	53.4	46.6
Nov 2018	261150	229123	490273	53.3	46.7
Dec 2018	207108	197689	404797	51.2	48.8
Jan 2019	191437	189886	381323	50.2	49.8
Feb 2019	161646	180700	342346	47.2	52.8
Mar 2019	217306	218688	435994	49.8	50.2
Apr 2019	239111	230147	469258	51	49
May 2019	377156	315573	692729	54.4	45.6
Jun 2019	693719	700129	1393849	49.8	50.2
Jul 2019	346328	382396	728724	47.5	52.5
Aug 2019	363149	374052	737201	49.3	50.7
Sep 2019	356729	300943	657672	54.2	45.8
TOTAL	**3736314**	**3599972**	**7336286**	**–**	**–**
AVERAGE	**311359.5**	**299997.7**	**611357.2**	**50.9**	**49.1**